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VEGETABLE SEED TREATMENT

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Bulletin No. 597

VEGETABLE SEED TREATMENT[1]

E. E. CLAYTON[2]

INTRODUCTION

Seed treatments to destroy disease germs carried on or within the seed have been used for many years. From the beginning difficulties due to seed injury have been encountered, and, as the result of extensive researches, improvements providing greater safety and convenience have been constantly introduced. Thus with wheat treatments, we have seen in recent years, first, the substitution of formaldehyde for copper sulfate, and the replacement of formaldehyde in turn by copper carbonate dust. On the other hand, less effective methods have been replaced by more effective, even at the expense of reduced safety. Thus, the hot water method of treatment for cruciferous crop seeds gives vastly better disease control than did the old mercuric chloride soak, and, wherever growers have come to realize the difference, it has come into general use, though known to be more laborious and hazardous.

The introduction of the organic mercurials, such as Semesan, has recently supplied the vegetable grower with a seed treatment which actually protects the seed and very young seedling against decay by soil organisms, and hence greatly increases the possibility of securing good stands. The question of seed decay is especially important under glass and with early plantings made in the open.

Following the new developments new questions have arisen. Some have claimed growth stimulation as the result of certain forms of seed treatment, and these claims have been completely refuted by others. Some reports have indicated that copper compounds might be just as effective, and perhaps safer to use, than the organic mercurials in protecting seed against decay. Again, reports of seed injury have been received which were very difficult to explain. All these things while quite aside from the primary purpose of seed treatment—the destruction of seed-borne disease—are of the greatest practical im-

[1]The information presented in this bulletin is based on experiments reported in more detail in Technical Bulletin No. 183 of this Station.

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portance. In the work reported here, covering a period of 9 years, we have sought to find the answer to some of these problems. The complications encountered in work of this sort are tremendous, and it has only been by repetition of tests over a number of years that a balanced judgment has been possible.

STIMULATION AND RETARDATION OF PLANT GROWTH BY SEED TREATMENT

It is possible to cause very striking stimulation of growth and yield by seed treatments. This has been observed many times in the

FIG. 1.—STIMULATION OF THE GROWTH OF BEANS BY SEED TREATMENT.

The number of plants in each row is about the same, but the plants in row 2 are much larger and the foliage a darker green. Row 1 sown with untreated seed; row 2 sown with seed dusted with 50 per cent copper tartrate; and row 3 sown with seed dusted with 50 per cent copper acetate.

greenhouse, and a few times in the field. Thus, in 1928, bean seed of the variety Bountiful was treated with a variety of dusts. As soon as the plants were above ground it became apparent that the plants of some lots were growing more vigorously than those of others. Figs. 1 and 2 show the marked differences in growth and yield. There

was a great difference in the color of the foliage which is not shown by the photographs. The check and copper acetate treated rows were slightly yellow green in color, while the copper tartrate treated seed produced plants with leaves of a deep green color. There were no significant differences in percentage stand and the marked yield differences could be attributed entirely to the more vigorous growth of the plants in the stimulated plats.

The results of this experiment were very clear cut and, taken alone, might be cited as proving the stimulating value of dusting seed with copper tartrate. This same experiment, however, was repeated with the same seed later in 1928, and no stimulation of growth re-

FIG. 2.—THE CROP OF BEANS PICKED FROM THE ROWS SHOWN IN FIG. 1.

The copper tartrate treatment (2) of the seed greatly increased both the growth of vines and the yield of beans. The copper acetate treatment also was of some benefit (3). This striking stimulation of growth and yield was not duplicated in later tests with the same seed and treatments.

sulted from any treatment. The experiment was then repeated twice in 1929 and twice in 1930, and in each of these tests the treated and untreated seed grew alike.

Another interesting instance of stimulation resulting from seed treatment was observed with lettuce. A stock of lettuce seed was divided up and different lots given dust and liquid soak treatments with Semesan. Sowings of the treated and untreated seed were made at three different times. In the first sowing the plants grew alike, but somewhat better stands were secured with the untreated seed. In the second sowing there were no significant differences either in stand or rate of growth between treated and untreated seed. In the third sowing the results were very different. The treated seed

gave very greatly increased stands, and furthermore, plants from the treated seed were about twice the size of the untreated at the end of three weeks. This experiment afforded a good example of growth stimulation due to seed treatment, and also shows how it would be possible for three men to sow the same seed treated in the same way and honestly report entirely conflicting results. Many lots of lettuce seed were treated and sown both before and after this experiment, but this was the only instance of stimulation with this crop.

Stimulation is not confined to chemical treatments, for some of the most outstanding results were secured as the result of hot water treatments. With all methods of treatment, however, these stimulation effects were the rare exception and not the general rule, so there is no basis for claiming growth stimulation as an advantage peculiar to some particular form of seed treatment. The results cited above show that environmental conditions, over which we have no control, may have more to do with the occurrence of growth stimulation than the particular kind of seed treatment employed.

Retardation of growth as the result of seed treatment has been observed occasionally during the course of the experiments. A good example of such effect is secured by treating lima bean seed with Semesan dust. The treated seeds germinate and grow, but the roots and tops are smaller (Fig. 3), and the yield is correspondingly affected. Thus, in a representative experiment, the plants from treated seed averaged 23 per cent less green weight and produced 23 per cent less pods than plants grown from the same seed untreated.

IMPROVING STANDS BY SEED TREATMENT

Seed decay is an important problem with every vegetable grower but has been given very little attention by scientific workers. Vegetable growers must often sow seeds at times which are admittedly hazardous in order to mature crops to reach the most favorable market, and the failure of a sowing to give a satisfactory stand, due to the seed rotting in the ground, usually means a much greater loss than the mere value of the seed and the labor of replanting. Some vegetable seeds are very resistant to decay. Thus, radishes and the smooth-seeded pea varieties can be sown without hazard in the earliest spring. Other seeds, such as beans, corn, and cucumbers, are very subject to decay. In using seed treatment to protect against decay,

the dust treatments recommend themselves especially because of convenience, and also safety, as we shall see later.

In these experiments a careful comparison was made between a large number of dusts, using, in addition to the mercurials, copper carbonate, copper chloride, copper benzoate, copper acetate, creosote, beta naphthol, and iodoform, in various strengths and combinations. As these comparisons were continued from year to year, the more

FIG. 3.—THE HARMFUL EFFECT OF SEMESAN SEED TREATMENT ON ROOT DEVELOPMENT OF THE LIMA BEAN.

The three roots on the left are representative of plants grown from untreated seed; the three on the right of plants grown from Semesan-treated seed.

promising materials and combinations which gave the best results with specific crops were selected and compared in individual tests.

The general conclusion from continued tests was that the best mercurials, such as Semesan and Semesan Jr., were superior to dusts prepared from copper or other materials. The results also showed that there was very little gain from treating seeds to protect against decay during midsummer, when decay is not a problem. As every grower knows, sweet corn seed that is sown in the cool soil of early spring may rot, with a resulting poor stand, but may give a very good

stand if sown after the soil is warm. Dusting sweet corn with Semesan, Jr., consequently, is most needed for early plantings (Fig 4). Again, when seeds such as cabbage and cauliflower are sown early in the year, protection against decay is very profitable; while in localities such as Long Island, where these seeds are planted in the summer for a fall crop, protection against seed decay is unnecessary.

Available methods of seed treatment do not give satisfactory results with all kinds of seed. In these experiments corn, cucumbers, canta-

FIG. 4.—SWEET CORN RESPONDED ESPECIALLY WELL TO TREATMENT WITH THE ORGANIC MERCURIALS.

In this case, row 1 was sown with untreated seed and rows 2 and 3 with Semesan-soaked and dusted seed, respectively. There were about 25 per cent more plants in each of the treated seed rows.

loupes, cauliflower, cabbage, beets, tomatoes, and peppers have repeatedly given greatly improved stands as the result of seed treatment. On the other hand, all treatments have been harmful to lima beans (Fig. 5), and the results have been largely negative with string beans. Seed of both crops are especially liable to decay in the soil, particularly if chemical fertilizers are used in large quantity. Comparisons of four methods of fertilizer application, namely (1) in the furrow before planting, (2) on top of the row after planting, (3)

broadcast before planting, and (4) as a side dressing after the plants are above ground, showed that equally good stands were secured with the last three methods. Fertilizer applied in the row before planting, however, often caused a large portion of the seed to rot in the ground. Seed decay, as influenced by fertilizer, is most severe in dry seasons.

PREVENTION OF DAMPING-OFF BY SEED TREATMENT

Just as the germinating seeds are apt to be destroyed by soil organisms, so are the young plants subject to attack after they get

FIG. 5.—THE GROWTH OF TOPS AND THE SUBSEQUENT YIELD OF LIMA BEANS WAS GREATLY REDUCED BY SEMESAN SEED TREATMENT.

In this case the center row was sown with untreated and the two outside rows with treated seed.

above ground. This latter trouble, called damping-off, is especially serious with plants grown under glass. Treatment of the seed with organic mercurials or with copper compounds often gives partial control of damping-off in the greenhouse. To secure more effective control, however, we have found it advisable to supplement the seed treatment with two appplications of 0.25 per cent Semesan; the first treatment to be made shortly after the plants are up, and the second about 10 days later. In making these soil applications, sufficient

liquid is used to moisten the soil thoroly about the base of the stems, much as is done in treating cabbage plants for maggots. This combination of seed and soil treatments has repeatedly given complete control of damping-off, even under conditions very favorable for the disease.

SEED TREATMENT AND SEED INJURY

The purpose of this phase of the study was to determine how and when the treatments under consideration could cause seed injury, and what might be done to avoid this. In general, treatments with organic mercurials have been regarded as very safe, while hot water treatments are considered hazardous. In this country Semesan, and associated preparations, are the only organic mercurials widely used. In these tests, Semesan was compared with Germisan, Metaphen, mercurichrome, and similar preparations. None of these proved as safe for seed treatment as did Semesan. It has been reported, and we have found it true, that Semesan can be used at twice the recommended strength, or for double the recommended time, without affecting the germination of the treated seed, if sown at once.

Furthermore, seeds soaked in Semesan need not be rinsed after treatment. In these respects Semesan is distinctly superior to mercuric chloride. Thus, with the chloride any large increase in the duration of the treatment results in injury, and the same is true with mercuric iodide or cyanide. Lots of cabbage seed soaked ½ and 3 hours in 0.1 per cent mercuric chloride germinated 58.5 and 8.5 per cent, respectively, while similar lots soaked for the same intervals of time in 0.25 per cent Semesan germinated 52.5 and 62.25 per cent, respectively. With the mercuric chloride treatment, seed rinsed after treatment germinated 50.5 per cent and that not rinsed, 43.5 per cent: For Semesan treatments the values were for rinsed seed 61.3 per cent and for seed not rinsed, 60.5 per cent.

The extreme safety of the organic mercurial treatments on immediate seed germination being thus established, the next question studied was the effect of these treatments on the subsequent germination. To determine this many different kinds of seed were treated, stored, and then the germination tested at intervals. In general, Semesan dust treatment was compared with liquid treatments and with no treatment. The liquid treatment recommended for the

particular seed was always used, and also treatments for longer and shorter periods. The responses varied greatly with the different kinds of seed, and in some cases were very unexpected. Thus, with tomatoes, the liquid treatment recommended is 25 minutes soaking in 0.25 per cent Semesan, and the germination records of three lots of seed so treated were as follows:

66, 88, and 95 per cent after 1 month.
10, 22, and 25 per cent after 6 months.
13, 13, and 22 per cent after 12 months.
52.5, 55, and 62 per cent after 28 months.
50, 52, and 60.5 per cent after 48 months.

The germination of check and dusted lots of seed was good in all tests, and why the 25-minute soaking treatment should have given the above results is difficult to understand. Had the experiment been discontinued at the end of 6 months, we should have certainly reported that the seed was mostly dead. Treatments either longer or shorter than the recommended 25-minute soak were less injurious.

With carrot seed the results after 1 month were for dusted seed, 69 per cent germination and for soaked seed 58, 68, and 70 per cent; after 28 months, dusted seed gave 41.5 per cent and soaked seed 11, 17, and 17 per cent germination. In a later test the dusted seed still germinated well, while the liquid soaked seed was practically all dead.

Cucumber and beet seed also decreased in vitality rapidly after liquid treatments. On the other hand, the germination of cabbage, cauliflower, radish, rutabaga, and spinach seed was but little affected by liquid treatments.

In no instance did the Semesan dust[3] treatments reduce the vitality of any seed, whether the germination test was made after 1 month or 4 years. With cucumbers there was even indication that the dust treatment actually had a preservative effect (Fig. 6). Furthermore, when seed dusted and stored 4 years was planted in comparison with the same seed freshly dusted, the germination results indicated that the dust was still effective. In view of the uncertainty of the after effects of liquid treatments and the safety of the dust, it appears that the former should be used only on seed that is to be planted soon and the latter on seed that is to be held in storage.

[3]Rough-surfaced seeds, such as tomatoes, can be injured by using dust in excess of the amounts recommended.

EFFECT OF HOT WATER TREATMENTS ON SEED VITALITY

The hot water method of seed treatment is based on the principle that the thermal death point of certain disease germs is lower than that of the seed. The heat treatment has the advantage of being as effective inside the seed as on the surface, which is not true of chemical treatments. Consequently, infections such as black-leg and black-rot of crucifers, which are often introduced with the seed and which

FIG. 6.—THE GERMINATION OF CUCUMBER SEED SEMESAN DUSTED WAS AS GOOD OR BETTER AFTER STORAGE AS THE GERMINATION OF THE SAME SEED UNTREATED.

Liquid Semesan-treated seed, however, decreased in germination more rapidly. In the above test, made in 1930, row 1 was sown with seed that had been dusted with Semesan in 1926, stand 75.5 per cent; row 2 was sown with the same seed freshly dusted, stand 53 per cent; row 3 was sown with the same seed that had been liquid treated in 1926, stand 23 per cent; and row 4 was sown with the same seed freshly liquid treated, stand 42 per cent.

penetrate the seed coat, can be destroyed by hot water treatment, while surface disinfectants are only partly effective. The margin of safety with hot water treatments is not large, and any considerable increase in either temperature or exposure will cause serious seed injury.

Ability of seed to stand hot water treatment without injury is correlated with seed vitality, and seeds of low vitality suffer the greatest loss in germination from treatment. Figures for percentage germination differ depending on how the tests are conducted, but when the testing is done in soil in the greenhouse, we find that lots which germinate less than 60 per cent are more liable to injury than those which germinate above this figure. Thus, in a representative experiment, with 13 lots of seed, the average reduction in germination for the 6 lots germinating below this figure was 31 per cent, and for the 7 lots germinating above this figure, 14 per cent. The combination of low initial germination plus a large drop due to treatment makes it likely that such seed stocks would give a poor stand.

The need for a careful check on germination to eliminate weak seed stocks is a specific precaution that is required for hot water treatment. Chemical treatments do not affect weak lots of seed so unfavorably, in fact the organic mercurials often give striking increases in germination with weak lots of seed.

Studies of the effect of hot water treatments of different duration have shown that with a temperature of 50°C (122°F), immediate germination is not seriously reduced until the exposure exceeds 30 minutes. There is, however, a delayed toxic effect which is directly proportional to the length of treatment, regardless of how short this may be. Thus, seed soaked 30 minutes loses vitality more rapidly than seed soaked 25 minutes, and so on down. For this reason, it is not advisable to use hot water treatments in excess of the minimum required to destroy the particular organisms involved. With cauliflower and cabbage seed, we have found this minimum to be 18 and 25 minutes, respectively.

The development of combination heat and chemical treatments, through the use of hot solutions of various disinfectants, appeared to be a promising possibility, and extensive tests were conducted along these lines. The results were unfavorable, due chiefly to the great increase in delayed toxic effects from such treatments. The only safe combination treatment that can be recommended is hot water treatment plus dust, the latter being applied after the seed has dried. This combination would be suitable where the destruction of seed-borne organisms and protection against seed decay were both desired. Only two materials were found which, when added to the treating water, had a favorable effect. These were aluminum and zinc sul-

fate, and both, when used in small amounts (0.2 to 0.4 per cent), reduced the toxic after effects of hot water treatment with many lots of seed.

CONCLUSIONS

In experimental work with seed treatments much attention has been given to the efficiency of various processes in destroying specific seed-borne infections. The object of the investigation here reported, however, was to secure information on some of the indirect effects from seed treatments. Growers often hesitate to treat valuable seed stocks because of uncertainty as to how vitality and longevity might be affected. Others have incurred severe losses because of ignorance of the dangers involved. Again some forms of treatment are commonly reported to be growth stimulating and to increase the percentage and vigor of germination. Hot water treatments, on the other hand, are considered hazardous. The following results were secured in an effort to evaluate some of these factors.

Seed treatment can produce striking growth stimulation. These effects have resulted from plain heat treatments, as well as from various chemical treatments. They do not occur frequently and cannot be produced at will. Stimulation of growth cannot be claimed as a special advantage for any particular form of treatment.

Retarded growth may result from seed treatment. Thus lima bean seed dusted with organic mercurials produced smaller plants and lower yields.

Comparisons of mercury and copper dusts show that, while the latter have value in protecting seed against decay in the soil, the mercury dusts are, on the average, distinctly superior. Protective treatments were more effective with some kinds of seeds than with others. In these tests especially good results were secured with sweet corn, cabbage, cauliflower, cucumbers, cantaloupes, tomatoes, peppers, and beets. String beans, on the other hand, usually showed but little benefit; while lima beans, a seed especially liable to decay in the soil, were helped by no treatment, and were injured by many forms of treatment.

Chemical fertilizers applied so that they come in contact with the seed are an important factor in predisposing seed to decay.

Seed treatment with the organic mercurials gives some protection against damping-off. Satisfactory control of this trouble, however, was best secured by a combined seed and soil treatment.

Studies of the effect of seed treatments on seed vitality, showed that an organic mercurial, such as Semesan, was less likely to cause seed injury than other mercury compounds, such as the chloride, iodide or cyanide. Liquid treatments, however, while causing no immediate seed injury, do have a delayed toxic effect which greatly reduced the germination of some seeds after they had been held a time in storage. Semesan used as a dust did not reduce seed vitality in any test, and the dust treatments gave fairly effective protection even as much as 4 years after application.

Hot water treatments were especially harmful to seeds of low initial vitality. Cabbage and cauliflower seed of good vitality, however, was but little affected by treatments up to 30 minutes at 50°C (122°F). Hot water treated seed decreased in germination more rapidly than untreated seed, and hence should be treated only a short time in advance of the time of sowing. The addition of disinfectants to the treating water increased the danger of seed injury. A combination of hot water and dust treatment, however, was safe. Aluminum and zinc sulfates added in small quantity to the treating water exercised a beneficial effect on seed germination.